QUANTIFYING UNCERTAINTY AND KINEMATICS OF EARTHQUAKE SYSTEMS (QUAKES-A) ANALYTIC CENTER FRAMEWORK

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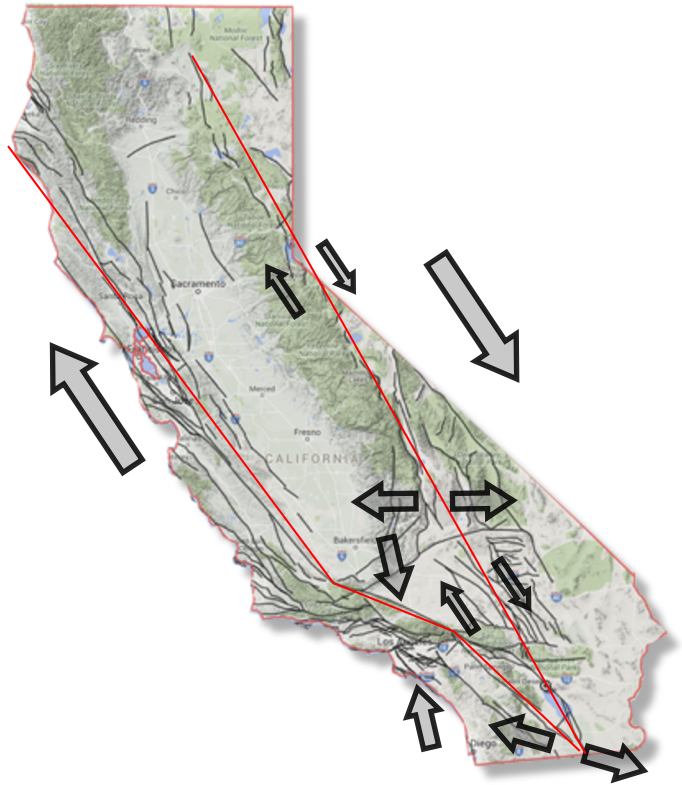
Objective

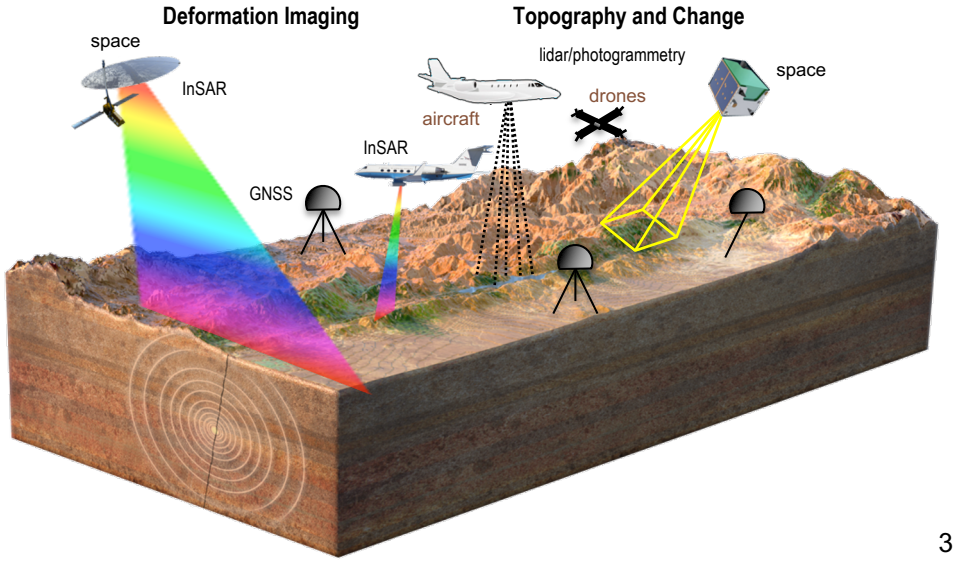
Create a uniform crustal deformation reference model for the active plate margin of California

- Fused InSAR, topographic, and GNSS geodetic imaging data
- Quantify uncertainties for the reference model
- Improve earthquake forecast models
- Improve understanding of the physical processes leading to and following earthquakes

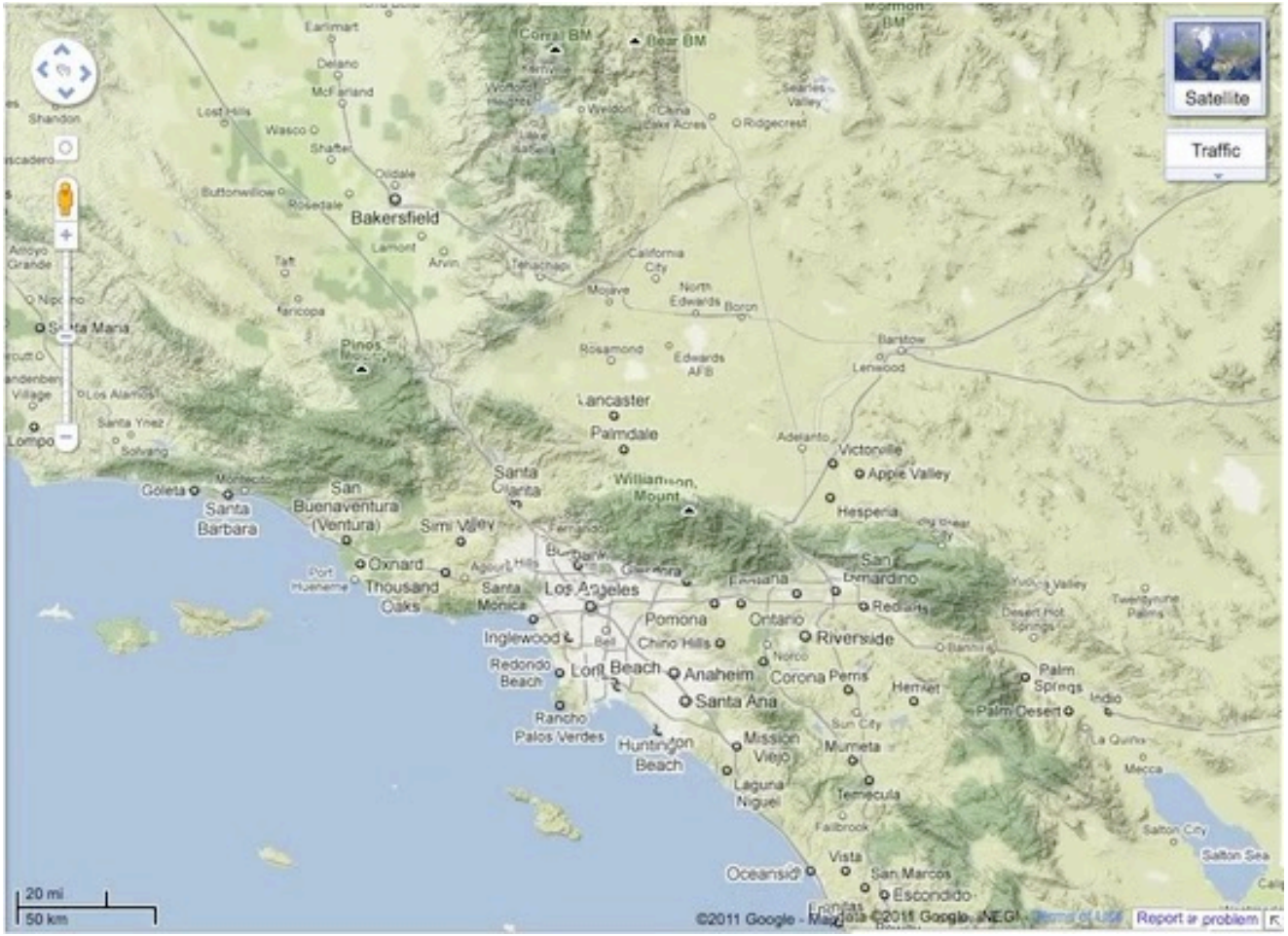


Approach

- Adjust UAVSAR processing with GNSS displacements and extract slip features
- Identify and rank active fault systems using GNSS cluster analysis
- Fuse and interpolate geodetic products to provide a uniformly sampled deformation field
- Assimilate and correlate the crustal deformation products into seismicity-based earthquake forecasts

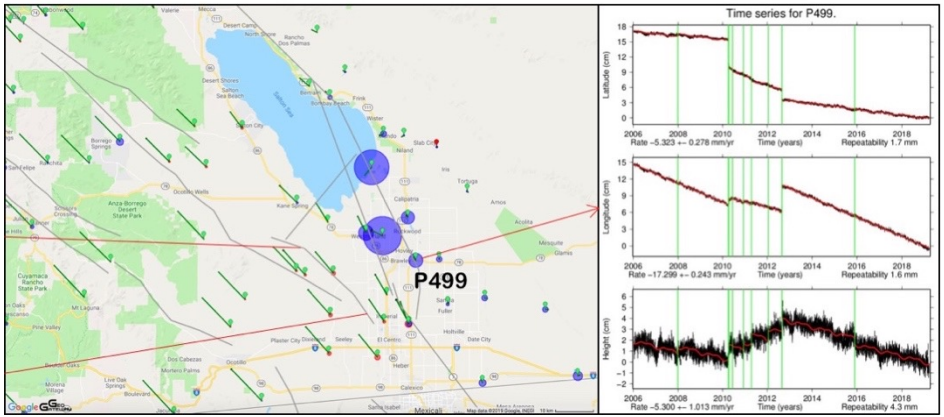


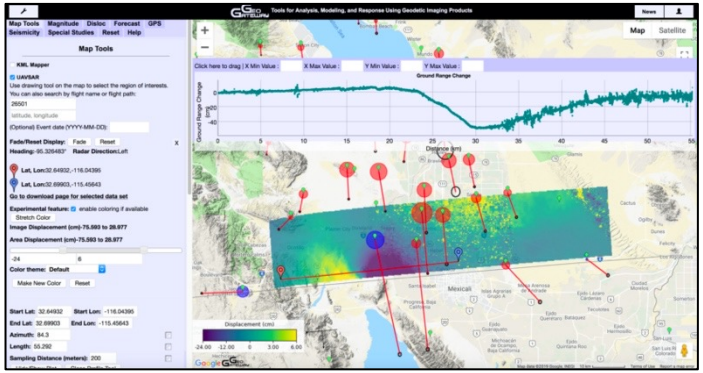
Conceptual View of Southern California Fault Motions



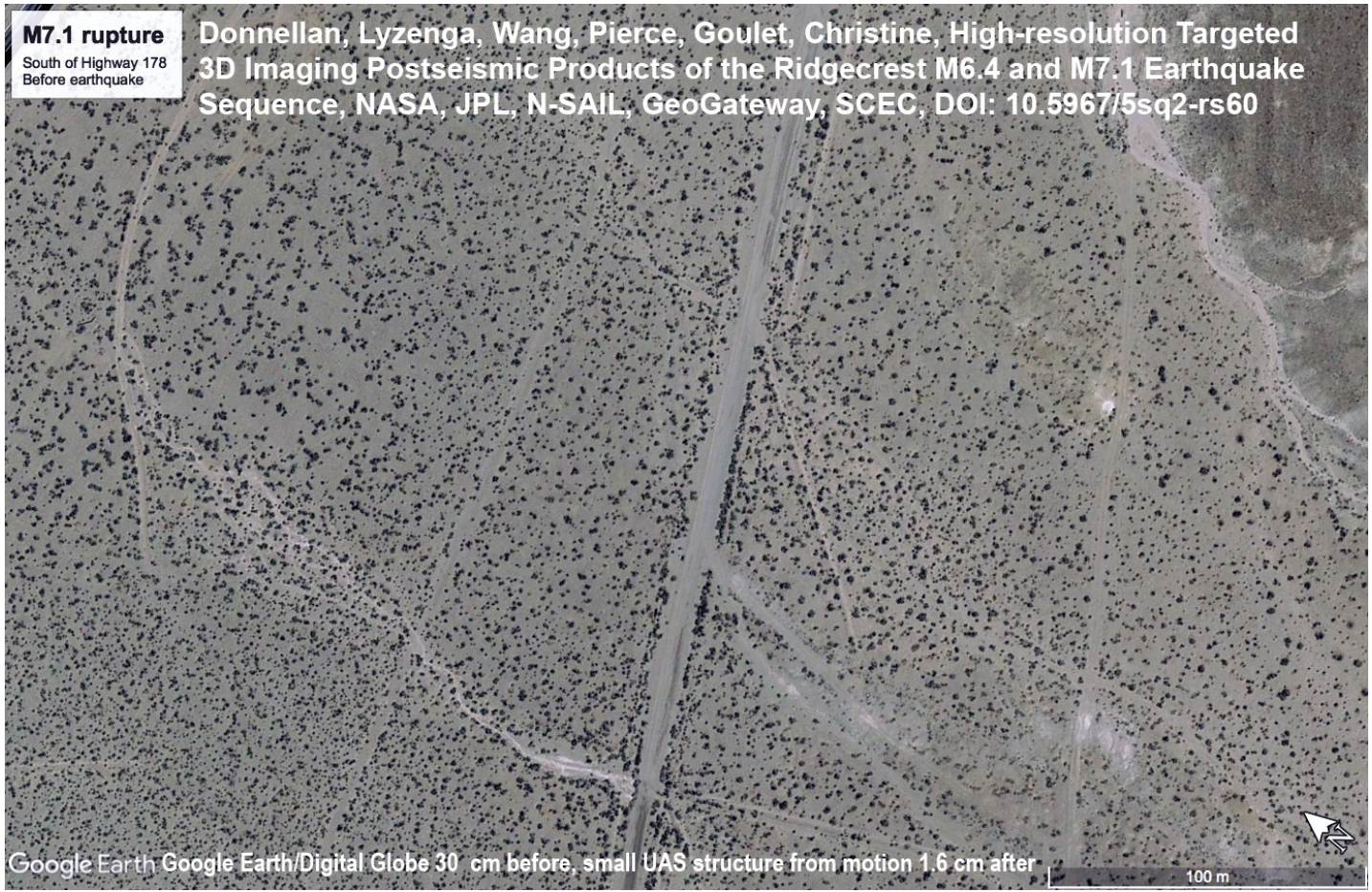
Data Types

- Fuse multiple geodetic methods to determine spatio-temporal variations in crustal deformation
- Construct a time-dependent uniformly gridded product
- Serves as reference for modeling and analysis

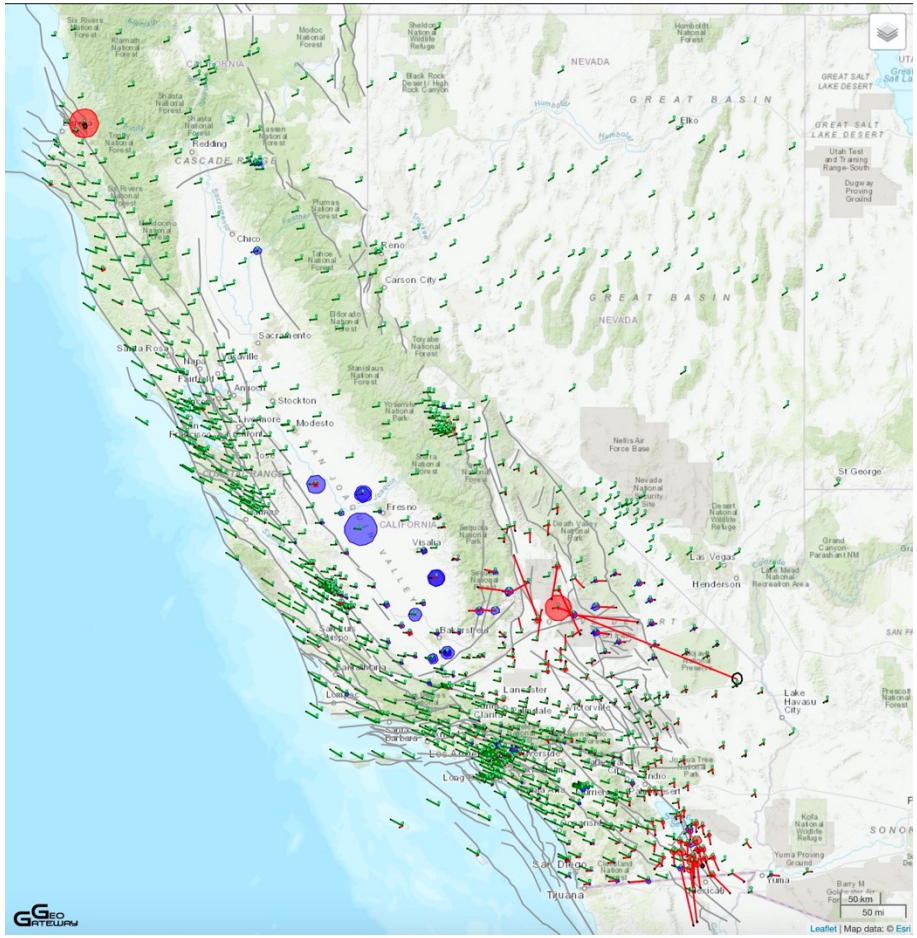


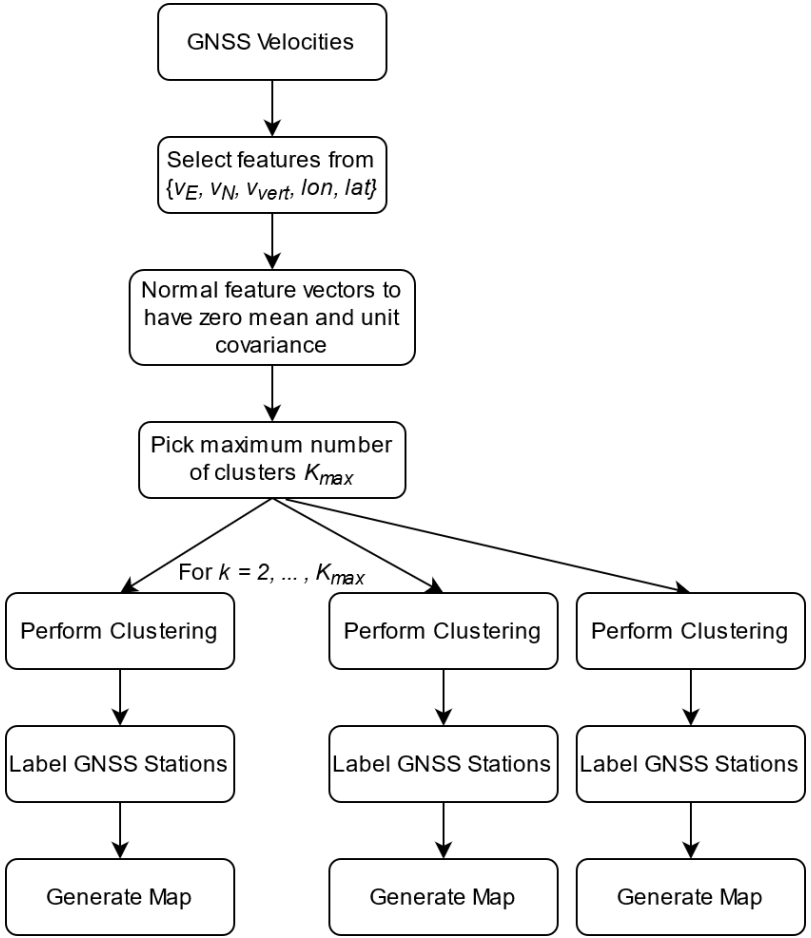


Stereo Photogrammetry also Indicates Discontinuities

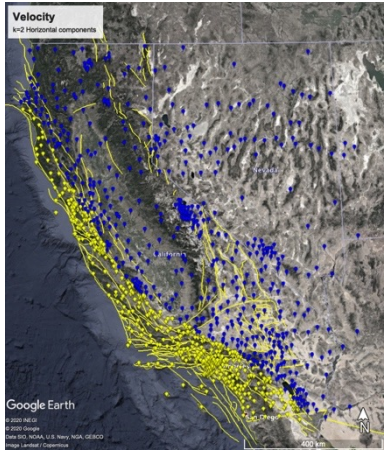


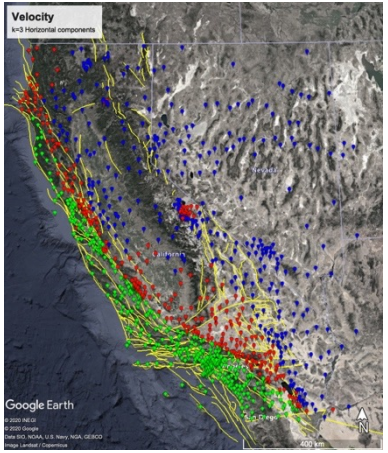
First Cluster GNSS Velocities

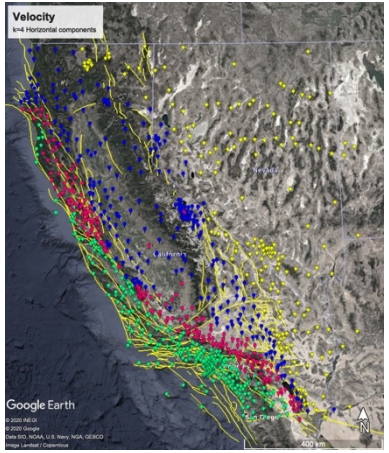


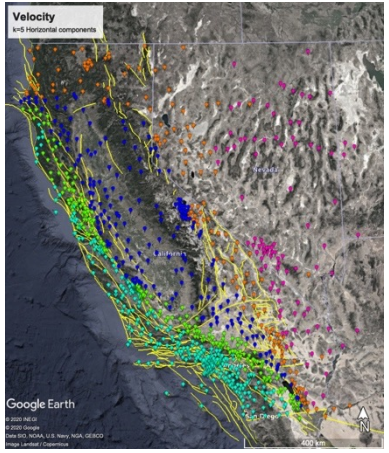


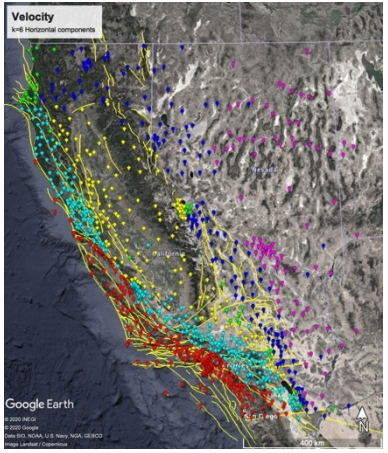
Clustered Velocities by Increasing Classes

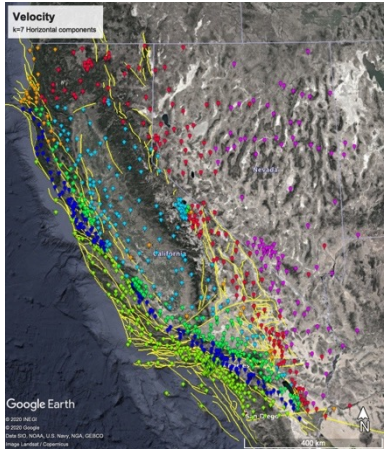




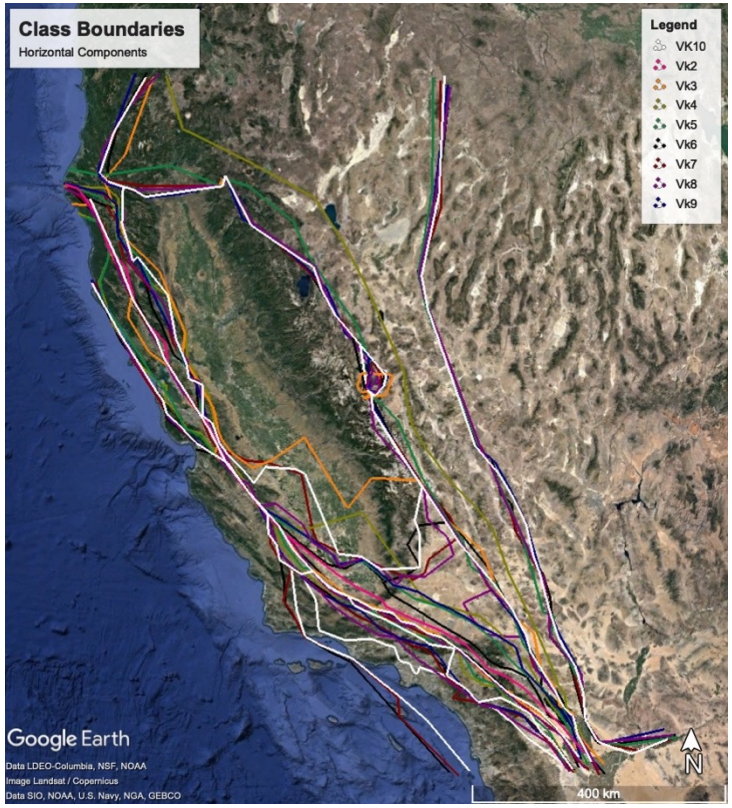




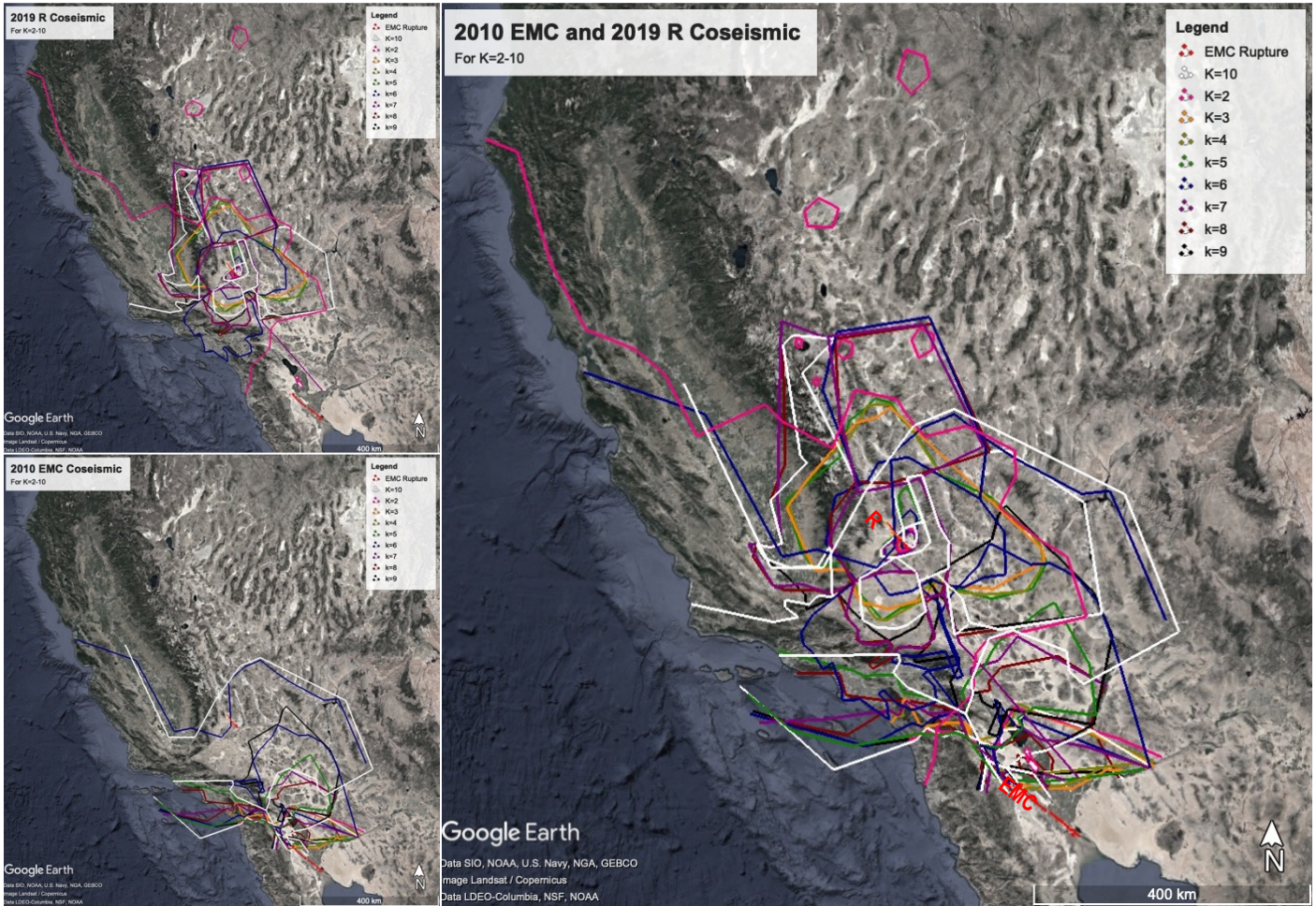




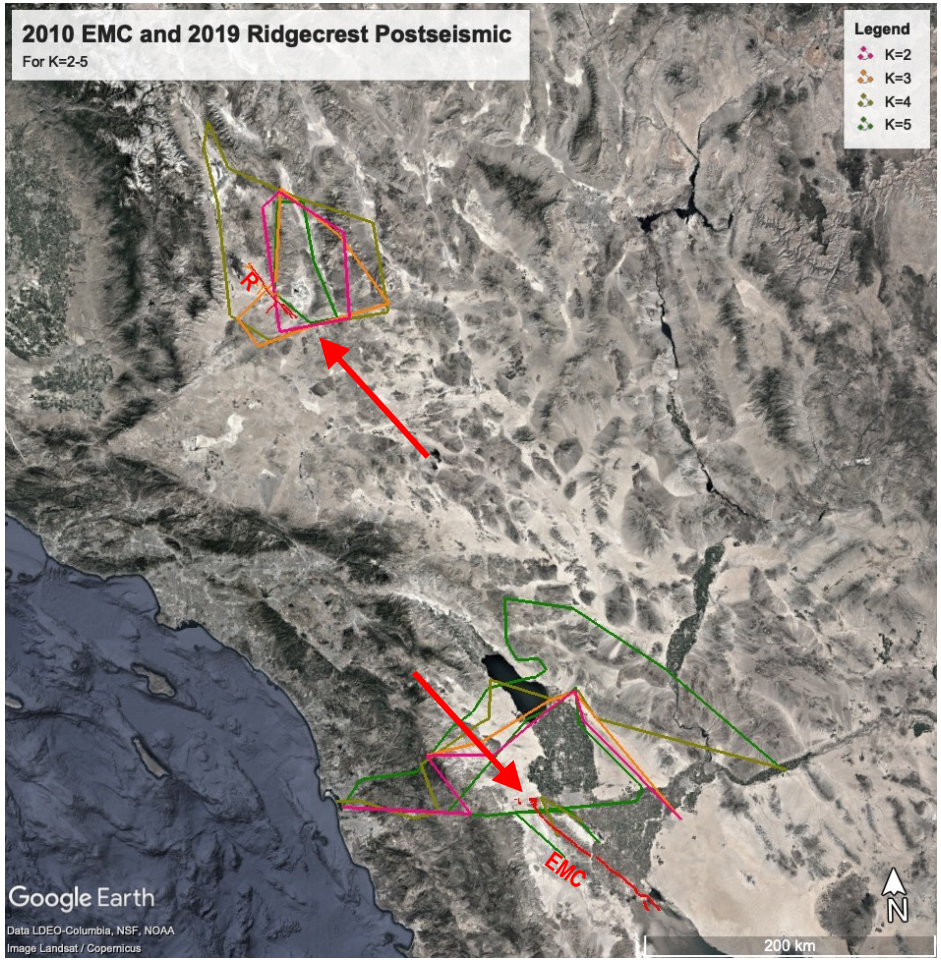
Boundaries all Classes



Coseismic Results

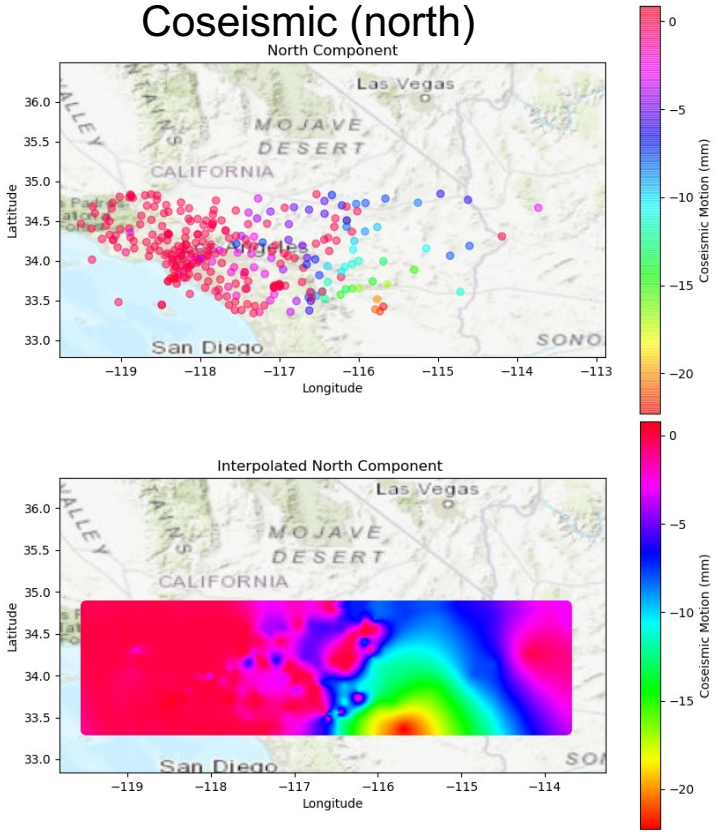


Postseismic Clustering

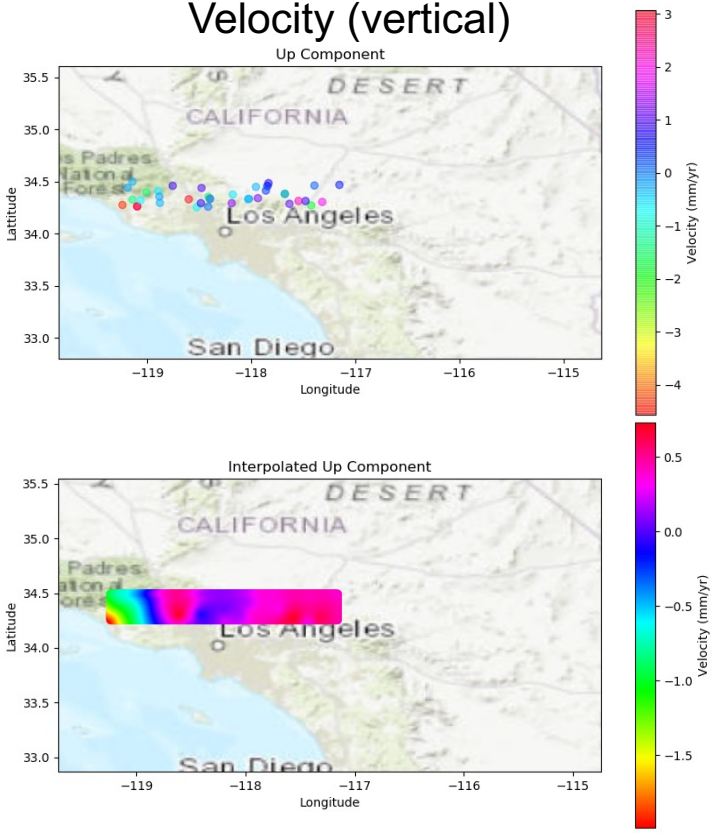


Interpolation

Coseismic (north)

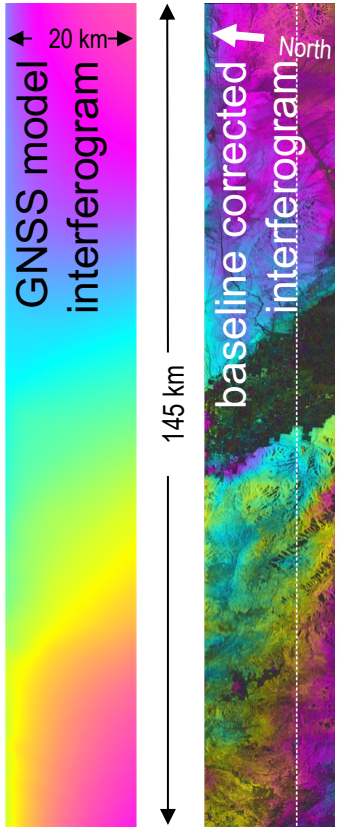


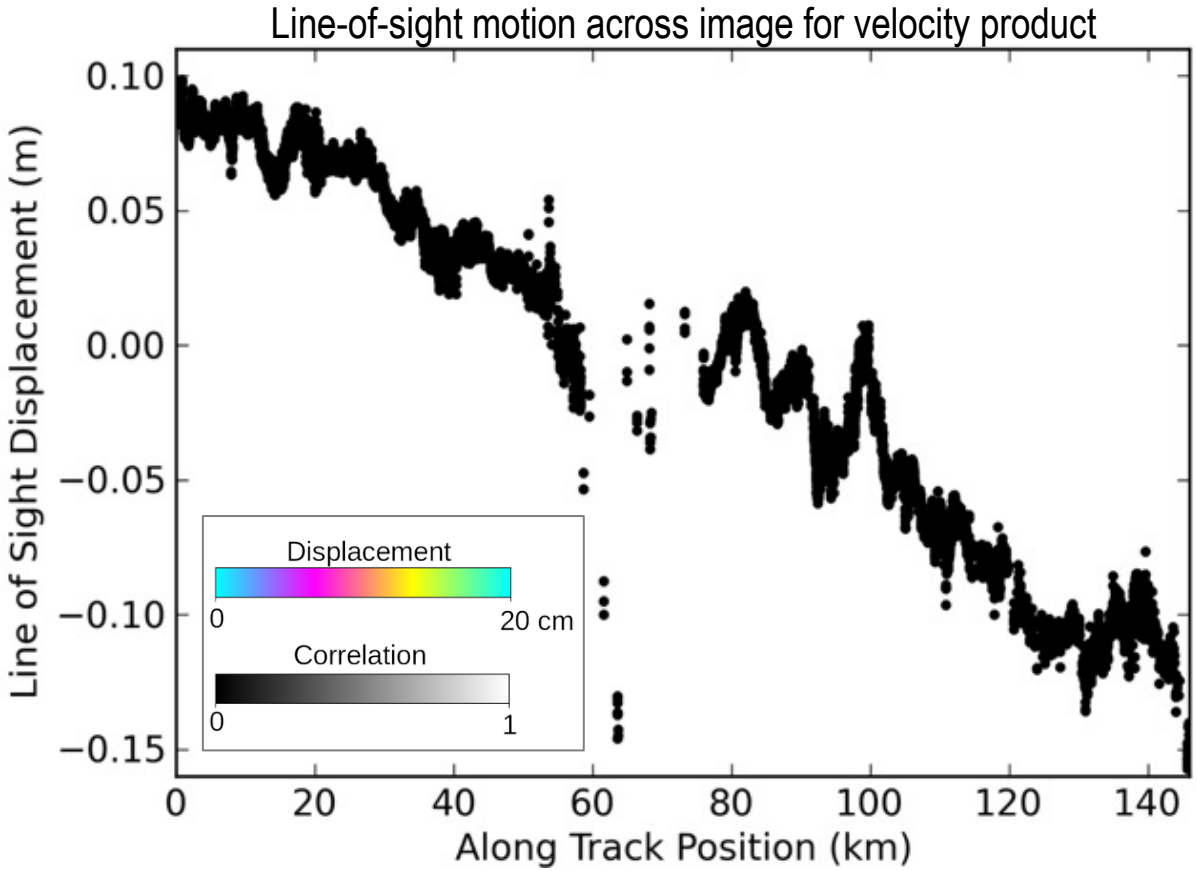
Velocity (vertical)



1. Creates synthetic interferogram for UAVSAR baseline adjustment
2. Creates initial uniform posting gridded deformation field

UAVSAR Baseline Adjustment

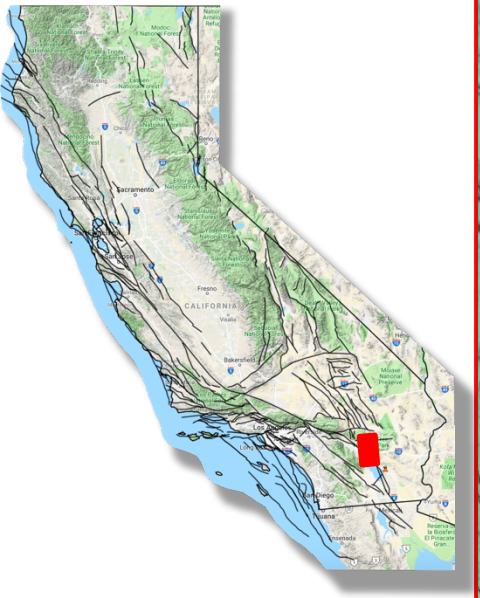


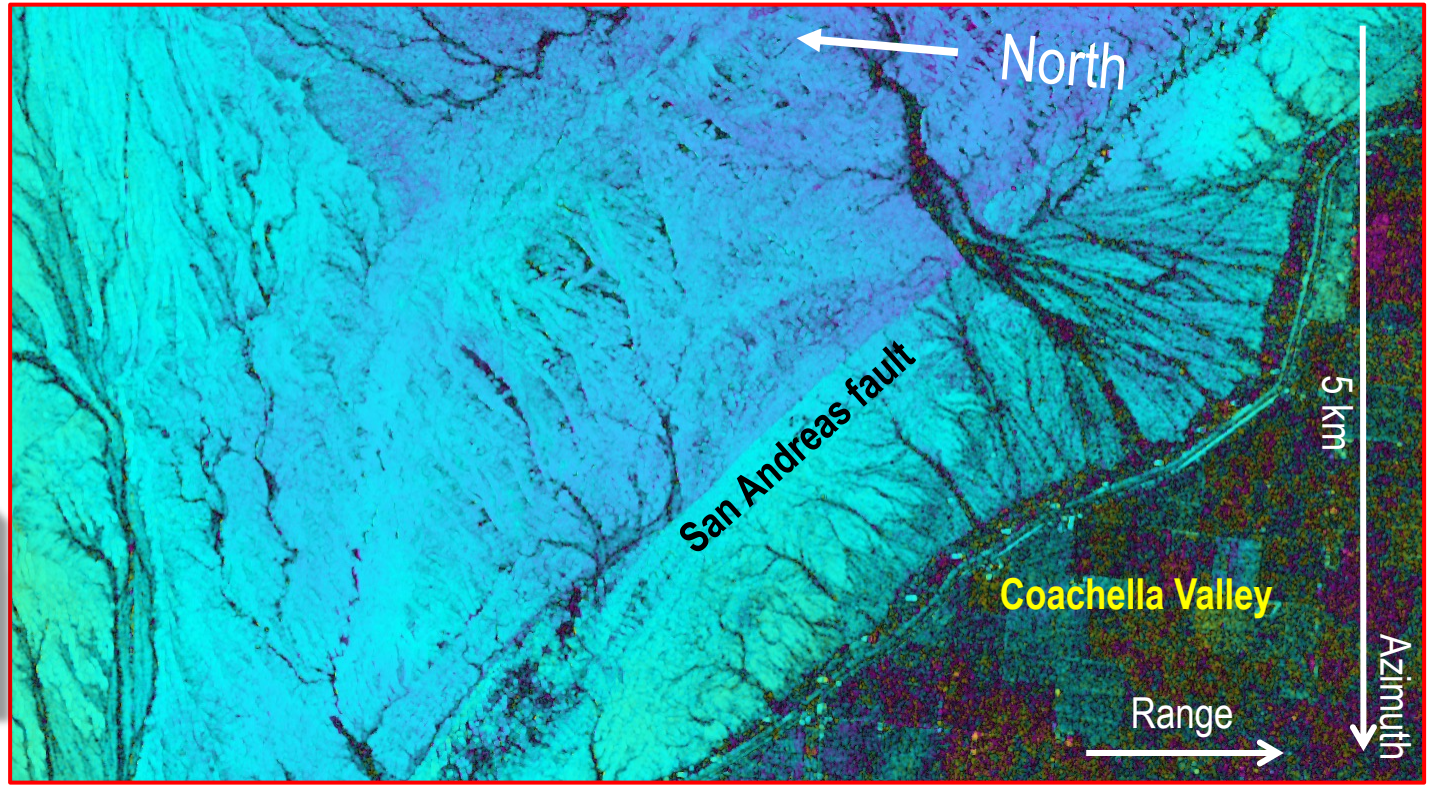


Enables extraction of plate tectonic motion and variations

Interferogram

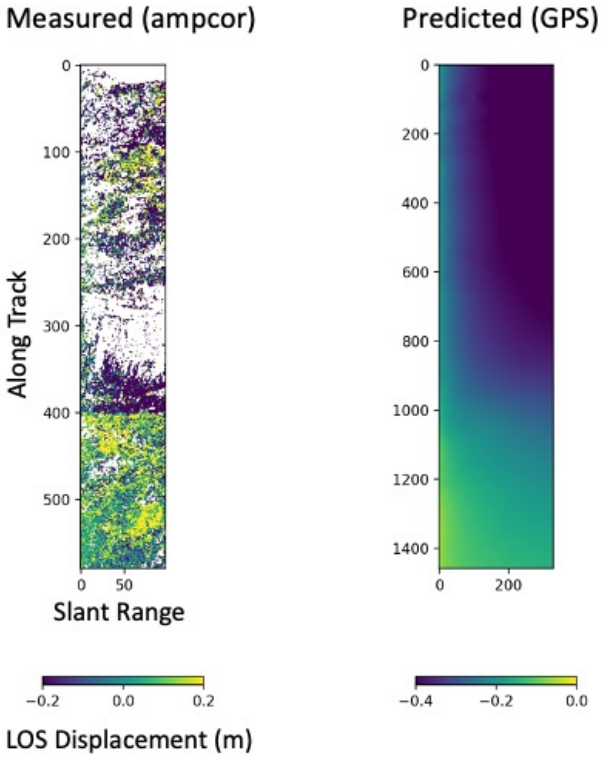
Shows far-field tectonic motion and near field fault slip

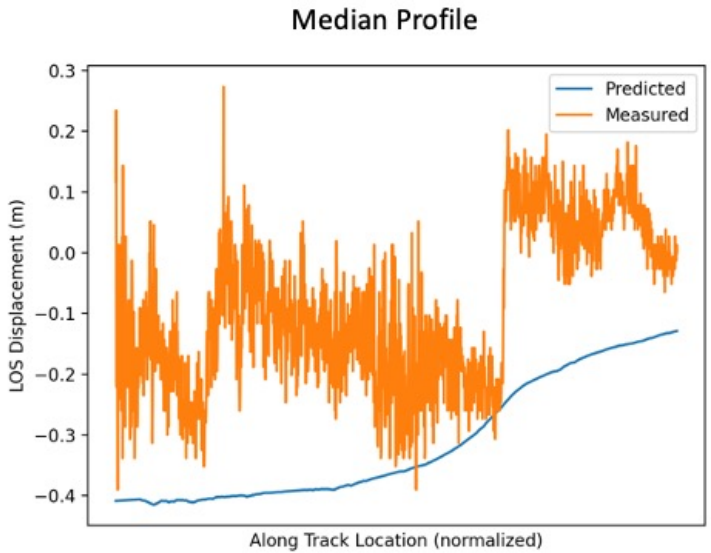




Still Working out Issues

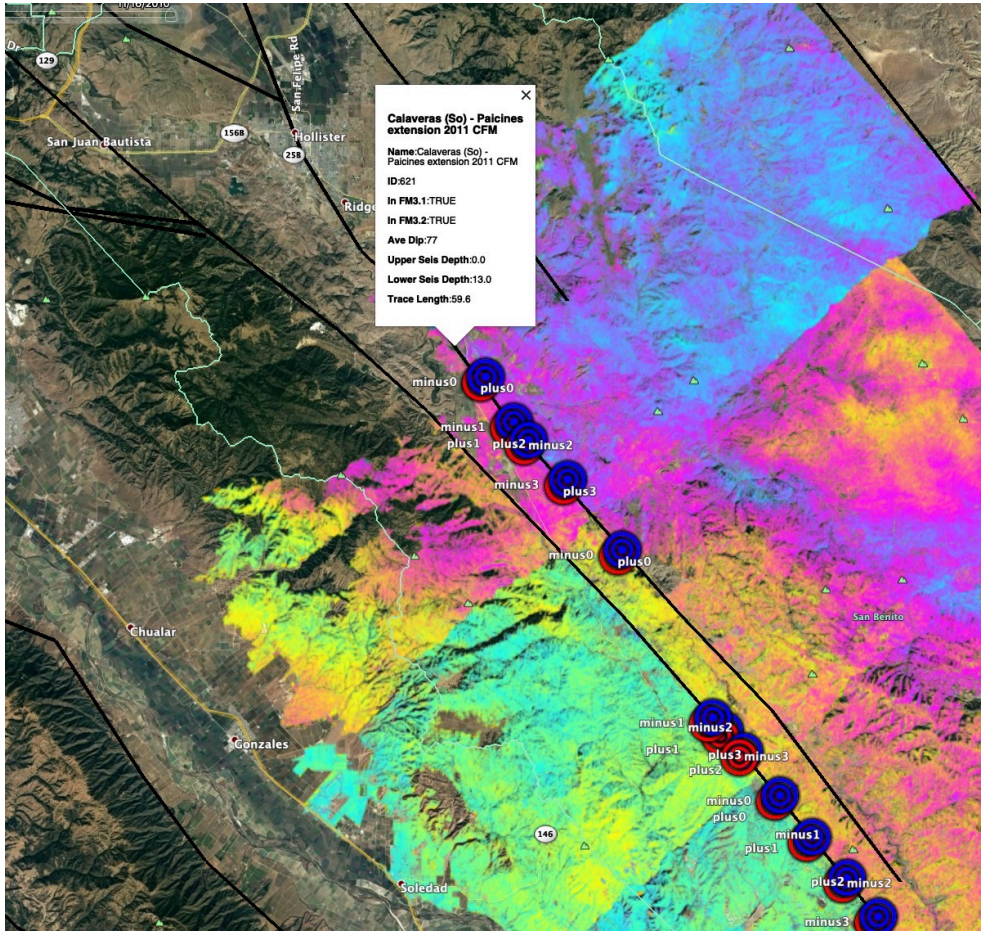
SanAnd_05014_09085-20025_10-4_091027-200910





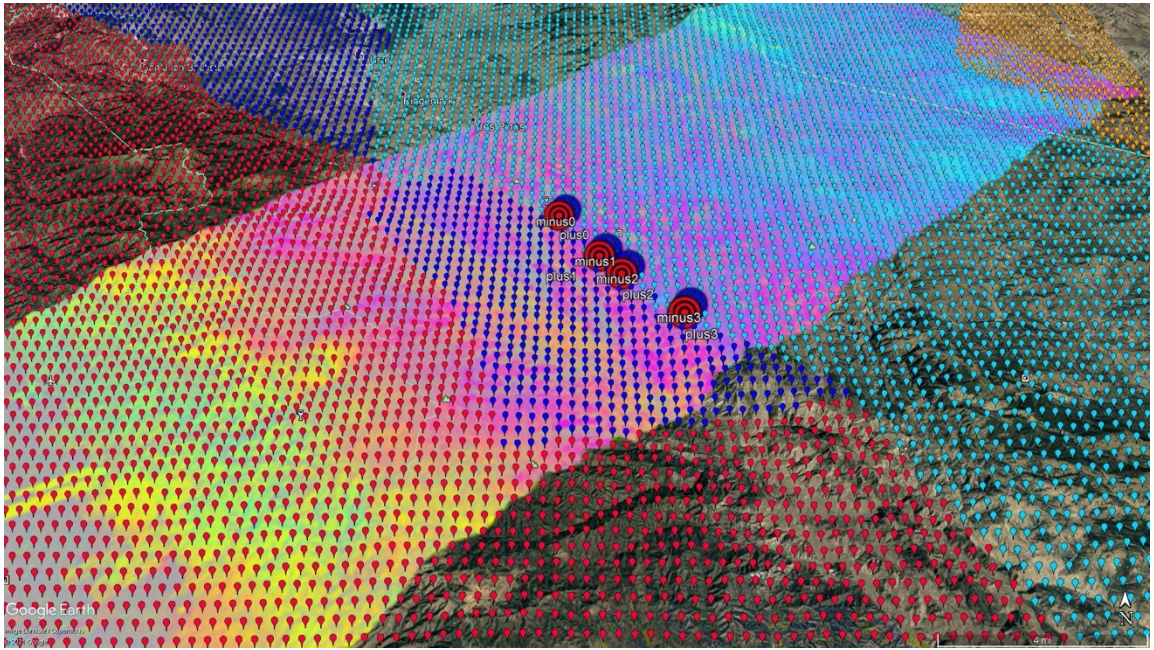
Combine Strengths of InSAR and GNSS

- Automatic generation of oppositional points (do-no-cluster pairs) successfully traces stepover from creeping SAF to creeping Calaveras fault with no human intervention
- Set fault boundaries from GNSS clustering analysis and identification of discontinuities in InSAR products



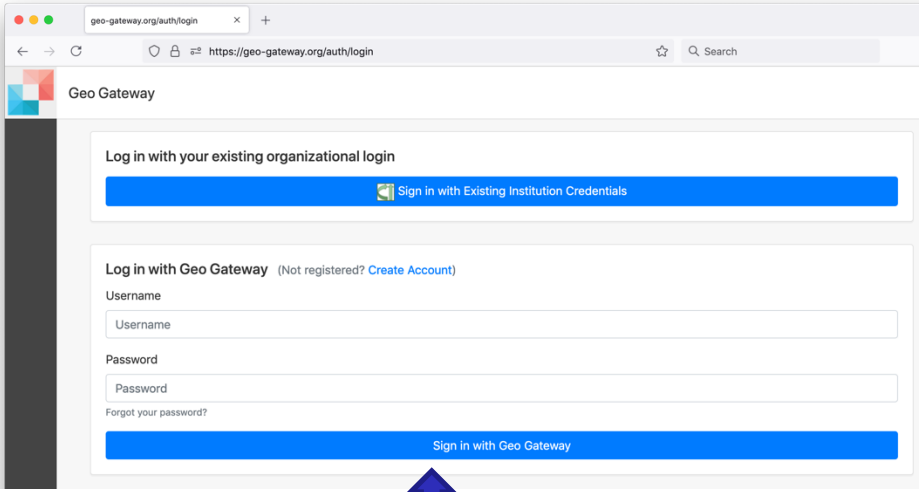
GNSS / InSAR Constrained Clustering

- UAVSAR image of creeping section of the San Andreas fault.
- Edge detection directs cluster locations
- Constrained clustering using COP K-means groups GNSS stations according to motion.
- Colored icons show 1:10 of InSAR pixel locations divided into clusters.
- Displacements can be estimated at InSAR pixel coordinates using ordinary kriging on a cluster-by-cluster basis.



ESIP Evaluation

- GeoGateway has been selected for usability evaluation by ESIP in partnership with the NASA AIST program
- Evaluation begin June 2021 and will last approximately 3 months
- Evaluators:
  - Jessica Job, USGS
  - Scott Marshall, Appalachian State University
  - Daniel Ponti, USGS
  - Paul Parsons, Purdue University
- Goal of evaluation: increase usability, help us refine the interface for target audiences, particularly educators



Integration of GeoGateway with Apache Airavata middleware and the Django Portal for Airavata completed.

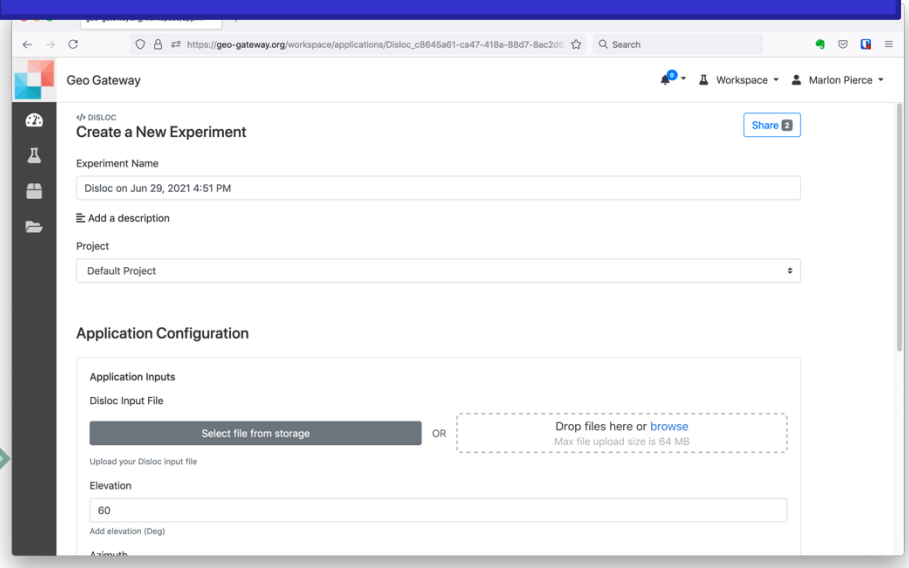
- GeoGateway now hosted on consolidated platform operated by IU.

Federated authentication and identity management for user accounts.

- Will support single sign-on with JupyterHub

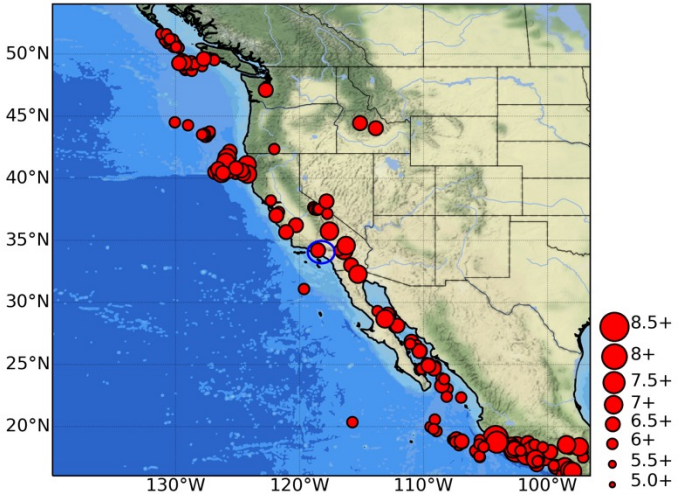
Ability to submit jobs to clusters and supercomputers.

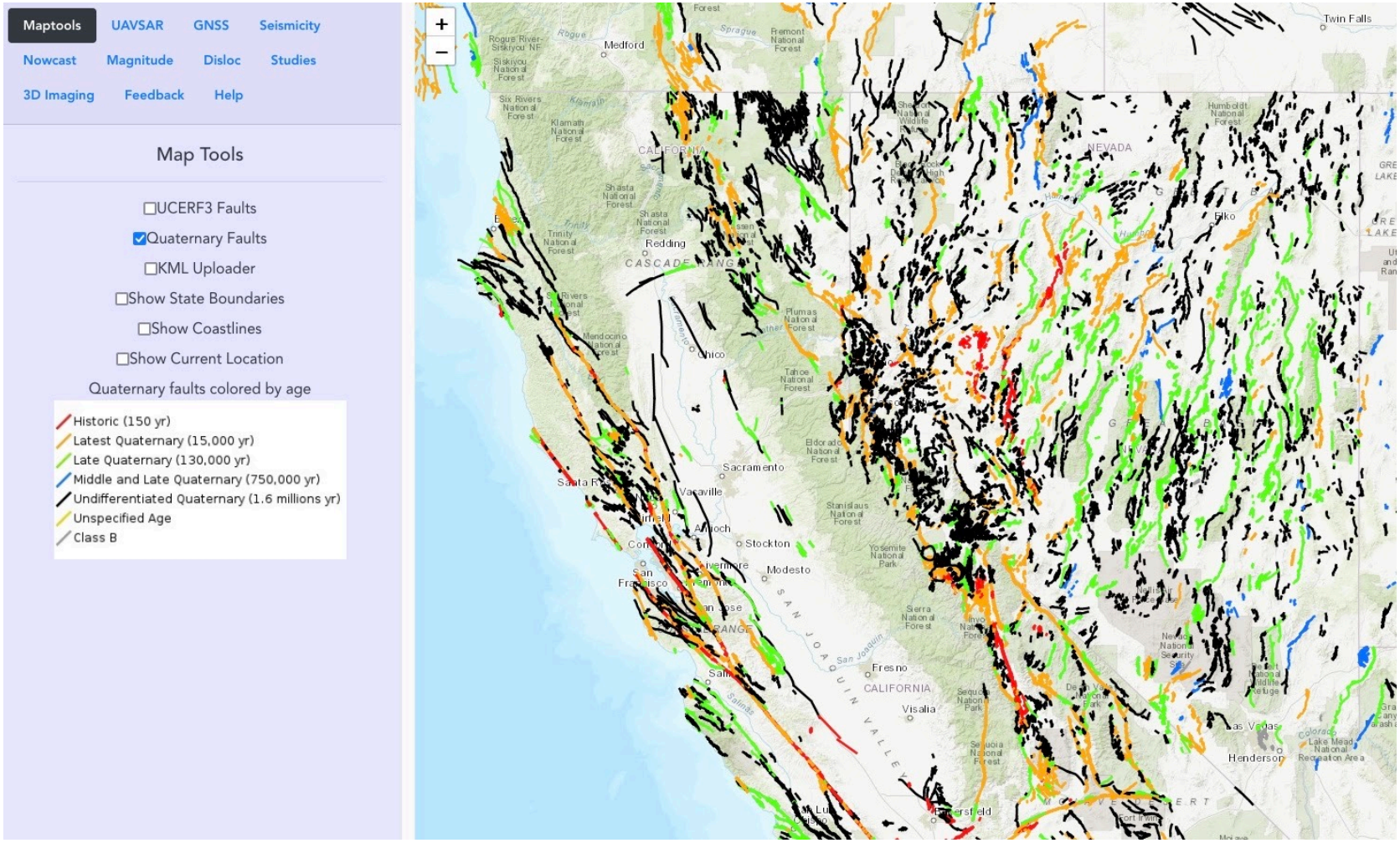
- We can now add several more applications requiring HPC



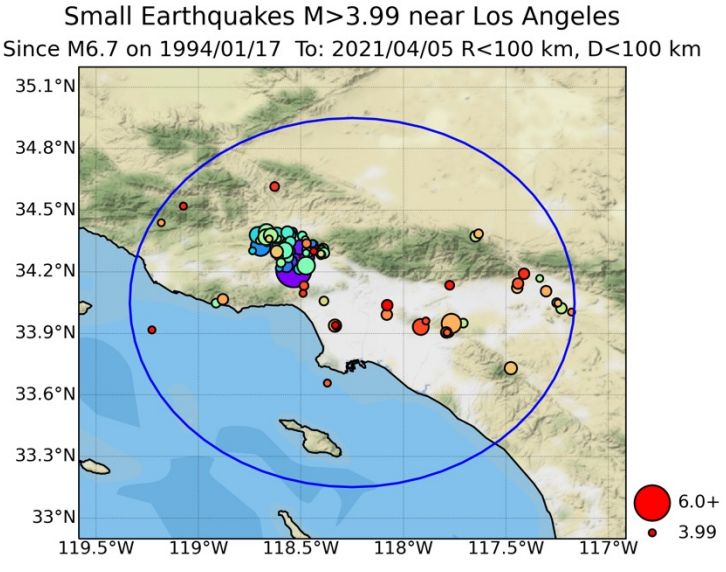
Recent Earthquakes

- Earthquakes occur frequently along the western coast of North America
- At right is a plot of significant earthquakes having magnitudes M>6 since 1980
- Between every M>6 earthquake there are on average about 65 earthquakes having M>4
- If we count the number of small earthquakes since the last large earthquake, we can compute a "nowcast" = an assessment of current risk

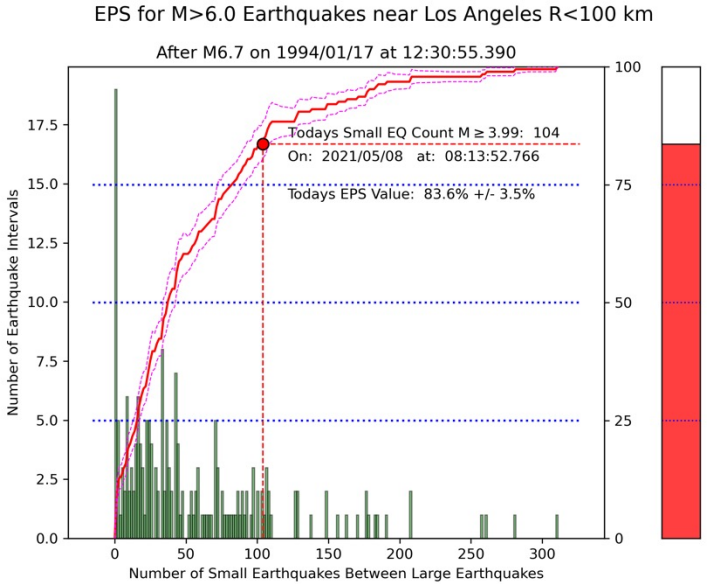



Maptools
UAVSAR
GNSS
Seismicity
Nowcast
Magnitude
Disloc
Studies
3D Imaging
Feedback
Help
Map Tools
UCERF3 Faults
Quaternary Faults
KML Uploader
Show State Boundaries
Show Coastlines
Show Current Location
Quaternary faults colored by age
Historic (150 yr)
Latest Quaternary (15,000 yr)
Late Quaternary (130,000 yr)
Middle and Late Quaternary (750,000 yr)
Undifferentiated Quaternary (1.6 millions yr)
Unspecified Age
Class B
CALIFORNIA
NEVADA
CASCADE RANGE
SAN JOAQUIN VALLEY
Medford
Redding
Chico
Sacramento
Vacaville
Stockton
Modesto
Fresno
Visalia
Twin Falls
Elko
Henderson

In the Los Angeles Area



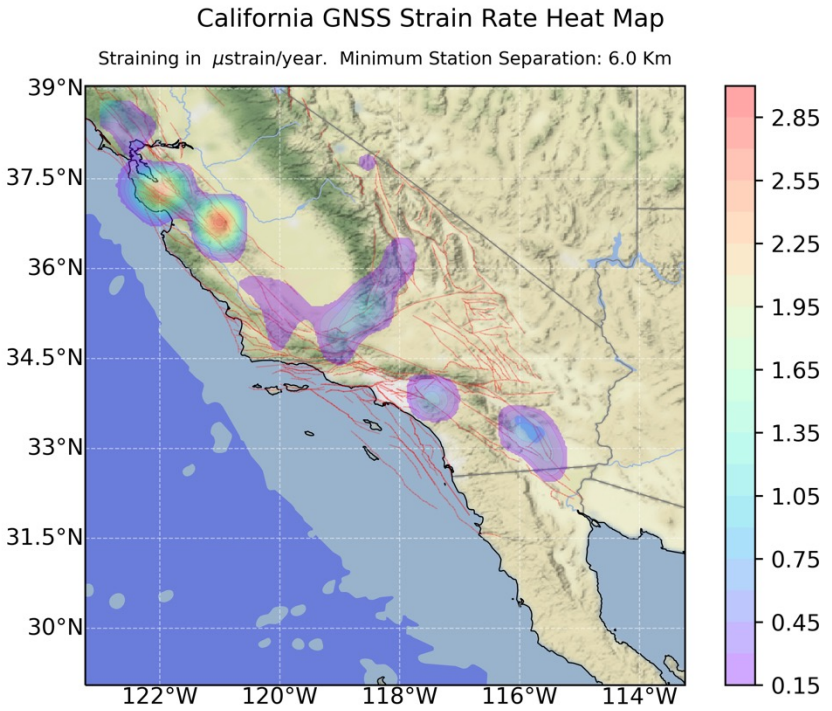
Small earthquakes since the 1994 Northridge earthquake



Nowcast indicates a current risk of 83.6%, meaning that the Los Angles area is 83.6% through a typical earthquake cycle

Strain Rate from GNSS

- We use the GNSS data from the PBO array in California to compute the station velocities
- The velocities can be used to compute the rate of strain at gridded points in California



Contours of Deviatoric Strain Rate Amplitudes in California

Summary

- Creating a uniform crustal deformation model that combines strengths from InSAR and GNSS
- Methodology being used for
  - UAVSAR baseline adjustment
  - Deformation model
  - Strain maps
  - NISAR GNSS cal/val
- User interface is at http://geo-gateway.org